mous Arctic currents which chill it, we should produce at once a greater increase of heat than is required by the floras. If, further, we impinged the Gulf Stream upon its shores, without cooling it down by floating icebergs upon its back, we might be able to induce at least an even more temperate vegetation to grow there.

Water is thus seen to be the great factor in distributing heat and cold in northern regions, and not land, as has been generally taught. Humboldt believed the rigorous climate of America to be due to high land stretching to the Pole; Lyell taught that with great polar seas and an excess of land at the equator, the hottest conditions possible on the globe would be produced, and that with land at the Poles and a great equatorial sea, the coldest conditions would ensue. A study of the isothermal lines leads to the contrary belief that the presence of land at the Pole, even if ice capped as Greenland is, would be less productive of cold than a polar ocean with free exits, for air has not the distributing power possessed by ocean streams, and when these are ice-laden the effect is still greater.

It only remains to call attention to such proof as we have, that these conditions really did exist in eocene time, and that the Arctic currents were actually shut off from the Atlantic in those days by continuous land which connected the two continents of Europe and North America. In the eocenes of Europe and North America we have evidence of a great, and, comparatively speaking, sudden rise of temperature, and this was followed in due course by a mingling for the first time of the floras and faunas of the two continents. That there was land communication to the north is further evidenced by the occurrence of types of both kinds in the floras now found upon the spots on which they grew. In further support of this theory we have the fact that no trace of sea-deposit of eocene age has ever been found in the polar area, all the vestiges of strata remaining showing that these latitudes were then occupied by dry land.

If we may assume that these conditions really did prevail, and that all the outlets into the Atlantic were closed by the elevation of the present sea-bed between 60° and 70° (where, I believe, the sea is even now shallower) into land of moderate elevation; with or without prolongations south to the 50th latitude; and the north of Greenland submerged, a temperature would ensue more than adequate to support all the plants yet found fossil in eocene or miocene Arctic beds. The result would be that the zone of greatest heat would be far north of the equator; for while the southern hemisphere was still cooled by the Antarctic currents rising to the surface, the North Atlantic would be practically a land-locked sea, cut off from southern cold by the tropics, from northern cold by land, and heated by the sun like the Gulf Stream or Red Sea. There is no need to suppose that the Gulf Stream washed its northern shores, for the temperature would then be raised in excess of what is required, but its aid may be called in to account for the even warmer previous periods evidenced by the older growths of Gleichenia and cycads.

It does not necessarily follow that cold did not then exist towards the Pole. Disko is 20° distant from it, and with an inclosed polar sea we should have a rapid lowering of temperature on the northern shores of the wide belt of land, and might have even a frozen ocean, perhaps as at present, with outlets on the side of Behring's Straits. The assumption that forests stretched to the Poles is not supported by the evidence.

The high temperature in these latitudes would be confined to the Atlantic; and that it was under the same laws as at present seems a reasonable supposition, since the American area even then maintained a relative coolness on account probably of the return and cooler currents being sheared to the west by the rotation of the earth.

To recapitulate. I believe the evidence to be in favour of the eocene age of the Arctic floras in question, and not miocene. I think that the temperature acquired by the plants—especially taking into consideration that their affinities with genera belonging to temperate regions is only inferred upon, in many cases, indistinct fragments—may have been over-estimated. There is no inherent impossibility indeed, that these extinct forms may not be the relics of a flora, like our present Arctic flora, specially adapted to bear a rigorous clime, and colour is lent to this by the abundance of the extinct McClintockia, about whose affinities we know nothing—a flora, perhaps, merely requiring the protecting cover of snow and sea-fog during winter. Finally, I believe that a comparatively slight change in the relative distribution of land and water, such as I have described, would alone account by itself for any fluctuations of temperature, of which we have any record preserved, in, at least, the tertiary rocks.

It does not come within the scope of the present subject, but it is worth consideration, whether wider channels still than those we now possess—some flowing from a more easterly point, so that our land might form the western coast of such a current—would not produce a glacial epoch, intensified by the absence of the Gulf Stream when there was no connecting isthmus (of which there is evidence in recent days) between the two Americas. The present distribution seems, at all events, one productive of more than average cold, as we become aware through the geological record, for the many and wide-existing channels conduct the Arctic waters south, and lower the general temperature of the ocean even to the Tropics.

J. STARKIE GARDNER

ON GAUSSIN'S WARNING REGARDING THE SLUGGISHNESS OF SHIP'S MAGNETISM[1]

Practical Rule and Caution

1. AFTER steering for some time on westerly courses expect—

1. (*a*) Westerly error if you turn to the north;

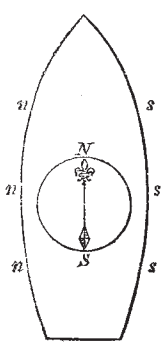
1. (*b*) Or easterly error if you turn to the south.

2. After steering for some time on easterly courses expect—

2. (*a*) Easterly error if you turn to north;

2. (*b*) Or westerly error if you turn to the south.

The diagram representing case 1 (*a*) illustrates the physical explanation, N and S representing the north and



south points of the compass card (or *true south* and *true north* poles of its needles), and the small letters, *s*, *s*, *s*, true southern polarity, and *n*, *n*, *n*, true northern polarity, induced in the port and starboard ends of deck beams and port and starboard sides of ship while steering east, and remaining for some time after she has been turned to north.

In the "Admiralty Compass Manual" Gaussin's warning is given with reference to the direction of swinging, in correcting the compass by magnets according to Airy's

[1] Being an abstract of a Communication by Sir Wm. Thomson, F.R.S., to Section A of the British Association at its last meeting (Dublin).

first method. In the Reports of the Liverpool Compass Committee and in Mr. Towson's "Information for Masters and Mates regarding Ship's Magnetism," instances of perplexing changes in the compass are given, and are referred to the same cause. The "sluggishness" of ship's magnetism, according to which it depends generally in part on the influence experienced some time before the time of observation, and not wholly on the influence at the time, seems to have been first definitely noticed and discussed scientifically by Sir Edward Sabine in his analysis of the results of the magnetic observations in the Antarctic Exploring Expedition of Sir James Ross in the *Erebus* and *Terror*, in the years 1840–41.

The practical rule and caution given above is of great importance in the navigation of iron ships. The amount of the error which may be found cannot be predicted for ships in general, nor for any particular ship except after much experience and careful observation. A small effect of two or three degrees,[1] such as that referred to in the Admiralty Manual as found in M. Gaussin's experience, may be observed in the course of quietly swinging a ship by hawsers or steam-tugs. If the ship under way is steamed round on the different courses the amount of the "Gaussin error" may generally be greater than if she is hauled round by warps; but we must not be sure that it will be so, because the *shake* of the screw which enhances the magnetisation on the east or west courses may shake it out again before the observation is made on the north or south courses.

A good practical rule in correcting the compass is, after having got it quite correct on the north and south courses, correct just half the error which is found after that on the south and north course, in the regular swinging of the ship.

The warning at the head of this article is particularly important for ships of war after firing guns when on easterly or westerly courses; if the course is then changed to north or south, and particularly if, after the firing, the change of course is effected under canvas, without the shaking of the ship's magnetism produced by the engines and screw.

The warning is also very important for ships steaming through the Mediterranean eastwards or westwards, and then turning south through the Suez Canal or north round Cape St. Vincent; and for ships steaming eastwards from America and then turning northwards or southwards into St. George's Channel.

MATHEMATICAL DRAWING INSTRUMENTS[1]

IN his preface the author states that we nowadays expect to find somewhere in print an account of the little mysteries of any particular art, and that partly with the hope of enabling this expectation to be fulfilled, and partly to meet the constant inquiries made respecting certain of the more complicated instruments manufactured by him, he has written his book. The author offers as an apology for any shortcomings in his work, that he is conscious his powers are greater with the lathe and file than in the ways of gentle rhetoric. In our opinion this is unnecessary; we would rather have had the file marks more distinct, and the technical details of construction not so carefully polished out in the work before us as in the well-finished instruments for which the author is so well known. The drawing instruments in most common use, pen, compasses, and dividers, are first described, and the patterns most recommended are illustrated; the type of these instruments now in use seems to meet all requirements, and if of the best quality, appears to require little or no improvement; the needle-point, however, shown on p. 34 (Fig. 1), adapted to compasses or pricker, is an improvement in steadiness on the old form, which was always liable to a little play. The earlier chapters will probably be of use to the beginner in facilitating his choice of the requisite instruments for his work, but he must recollect that dexterity in their use,

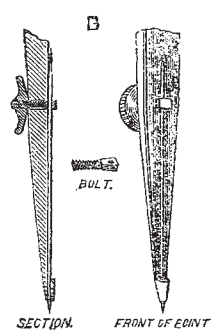


FIG. 1.

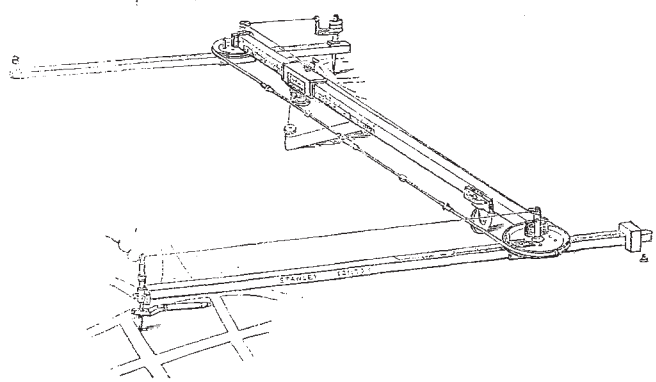


FIG. 2.

even if of the most improved form, can only be acquired with very considerable practice; much time and temper may be saved by the use of good instruments, and there is nothing particularly meritorious in the production of good work with bad instruments if good ones are within his reach.

Of the more complicated instruments next described, some must be regarded rather as mechanical curiosities than of every-day use; others, however, are indispensable where accuracy and the saving of time are of importance; as chief among these we select the eidograph and planimeter. A plan can be reduced or enlarged by dividing it into small squares and filling the details contained in each square into the corresponding squares ruled on the sheet prepared for the copy. This is a tolerably rapid process when the plan is simple in character, and with the help of proportional compasses a good draughtsman may attain considerable accuracy, but for a complicated plan or where great exactness is required, either the pentegraph or eidograph is indispensable. The author justly expresses astonishment at the little use at present made of the eidograph as compared with the pentegraph; the latter as made in this country appears for large work a most clumsy contrivance, offering much unavoidable resistance to motion, and even if made on the most improved Continental pattern is much less handy than the former. The eidograph, as improved by the author, is shown in the cut (Fig 2).

[1] Much greater effects than this are actually found in the cases of gun-practice and of long steaming on easterly or westerly courses referred to below.

[2] "Mathematical Drawing Instruments," by William Ford Stanley. (London: E. and F. N. Spon, 1878.)